PCT

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(54) Title: MAGNETIC-TAPE RECORDING/REPRODUCING ARRANGEMENT COMPRISING A CODING DEVICE

(57) Abstract

A magnetic-tape recording/reproducing arrangement of the "helical scan" type adapted to record and/or reproduce a digitally coded video signal comprises a coding device (3). In the recording mode the coding device (3) performs channel-encoding upon a digital recording signal (C) so as to obtain a channel signal (D) for recording on the magnetic tape (7.1). In the reproduction mode the coding device (3) performs channel-decoding upon the channel signal (H) read from the magnetic tape (7.1), so that a digital reproduction signal is obtained which is a replica of the original recording signal (C). For this purpose, the coding device (3) comprises a data sequence generator (3.3) adapted to generate a data sequence (E) defined by the polynomial $P(X) = X^{15} + X^A + 1$, where $A = 7$ or 8. Furthermore, the coding device (3) may comprise an XOR circuit (3.2) in which the signal (C, H) to be processed is combined with the generated data sequence (E), and selection means (3.1) to select the signal to be processed (C, H) from the recording signal (C) and the channel signal (H) in dependence upon the mode of operation of the recording/reproducing arrangement.

Magnetic-tape recording/reproducing arrangement comprising a coding device.

The invention relates to a magnetic-tape recording/reproducing
arrangement of the "helical scan" type adapted to record and/or reproduce a digitally coded
video signal, the arrangement comprising a coding device adapted to perform channel-
encoding upon a digital recording signal in order to obtain a channel signal for recording on

5   the magnetic tape and/or to perform channel-decoding upon a channel signal read from the
magnetic tape in order to obtain a digital reproduction signal. The invention further relates to
a magnetic tape on which a signal has been recorded in helical tracks and to a method of
recording a digitally coded video signal in helical tracks on a magnetic tape by channel
encoding of a digital recording signal in order to obtain a channel signal for recording on the

10   magnetic tape.

Such a magnetic-tape recording/reproducing arrangement is known inter
alia from European Patent Specification no. 0 476 767 (PHN 13537). The known
arrangement includes a coding device which converts n-nit words of the recording signal into

15   (n+m)-bit words of the channel signal for recording on the magnetic tape. This is referred to
as NRZ-1 recording. More specifically, a 24 to 25 bit conversion is described, in which one
bit is affixed to each 24-bit word in order to adjust the running digital sum value of the
channel signal as a function of time.

20   It is an object of the invention to provide a recording/reproducing
arrangement including a coding device which in a simple manner and without a deterioration
of the coding efficiency counteracts the repetitive generation of "false" synchronization
patterns.

To this end, the magnetic-tape recording/reproducing arrangement in

25   accordance with the invention the coding device comprises a data sequence generator adapted
to generate a data sequence defined by the polynomial $P(X) = X^{15} + X^A + 1$, where $A = 7$
or 8. Devices for obtaining a data sequence which can be described by an arbitrary
polynomial are known per se and are referred to as maximum-length sequence generators or
also as pseudo-random bit-sequence generators. Such generators are frequently used for

encrypting (scrambling) a signal in order to preclude decoding by unauthorized persons; the original signal can be recovered only by processing the scrambled signal in an identical and synchronized generator. For such a use a polynomial is selected which yields favorable properties as regards the security of the scrambled information; "hacking" the protected

5   information should be virtually impossible for those unauthorized. For use in a magnetic-tape recording/reproducing arrangement the choice of a data sequence generator should be based on other criteria. In order to elucidate these criteria and the arrangement in accordance with the invention some relevant aspects of a magnetic-tape recording/reproducing arrangement in accordance with a new digital recording system to be developed will now be described first

10   by way of example.

During a recording mode an incoming digital signal is divided into groups of 792 bits, after which error correction data is added. This results in recording-signal blocks of 856 bits each. These recording-signal blocks are applied to the coding device in the recording signal. In the coding device the recording signal is processed (channel coding) so

15   as to obtain the channel signal. Since the recording signal has a block structure (recording signal blocks) the channel signal also has a block structure; channel-signal blocks. Subsequently, a synchronization pattern is added to each channel signal block, as a result of which transport signal blocks are obtained. After some operations to prepare for recording, these transport signal blocks are recorded on the magnetic tape. On track as recorded on the

20   tape comprises 306 transport signal blocks. In a reproduction mode a detector checks the signal read for the presence of synchronization patterns. When these patterns are detected, the transport signal blocks can be located and the channel signal blocks can be extracted therefrom. Thus, the channel signal is reconstructed. In the coding device this signal is subjected to an inverse operation (channel decoding) in order to obtain the digital

25   reproduction signal. This signal is subjected to error correction, after which it is rid of the block structure applied in the recording mode. In this way, a replica of the original incoming signal is produced.

When an arbitrary signal is recorded it may occur that by chance the channel signal somehow corresponds to the synchronization pattern. As a result of this, the

30   detector will detect a "false" synchronization pattern during reproduction. This detector will generally be constructed in such a manner that a sporadically occurring "false" synchronization pattern does not bring the detector out of synchronization. However, if the incoming signal is highly periodic, for example in that the contents of successive video lines bear much resemblance to one another, "false" synchronization patterns may occur frequently

and at a substantially fixed location in the channel signal blocks. In such a case it will be difficult for the detector to distinguish between the desired synchronization patterns and the "false" synchronization patterns. The detector may then become desynchronized. If the incoming signal is a data stream from a computer or a digitally encoded audio signal this

5   may also result in a periodicity which gives rise to a regular pattern of "false" synchronization patterns in the channel signal.

In a magnetic-tape recording/reproducing arrangement in accordance with the invention the recording signal is processed so as to counteract the periodic occurrence of "false" synchronization patterns without the coding efficiency being affected by this

10   processing. For this purpose, the recording signal is combined with a data sequence which is generated by the data sequence generator and by which the recording signal is scrambled. The data sequence comprises a maximum-length sequence, which meets the following design criteria:

1).   The recording signal blocks should be scrambled with different channel sub-
15   sequences in order to preclude recurrent "false" synchronization patterns as a
                  result of the periodicity in the input signal.

2).   The maximum-length sequence should be short to prevent long sequences of
                  only zeros or only ones from being generated, because this makes it more likely
                  that such sequences also occur in the channel signal. Such sequences are less
20   suitable for transmission via a magnetic tape and, besides, no edges occur in
                  such a sequence. (An edge is a transition from a zero to a one or the other way
                  round.) In the recording mode such edges are necessary to synchronize a phase-
                  locked loop by means of which the bits are reconstructed from the signal read
                  from the tape. The absence of edges in a part of the signal can bring the phase-
25   locked loop out of synchronization. Therefore, in order to preclude this, the
                  maximum-length sequence should be short, i.e. the highest power in the
                  polynomial should be low. The first criterion can be met roughly by selecting a
                  maximum-length sequence of such a length that the sequence is non-repetitive
                  over a long period. This period can, for example, be a period of time
30   corresponding to five video pictures. Such a period of five video pictures is
                  commonly used as a unit in editing video recordings. This period corresponds
                  to 12 tracks on the tape, i.e. to $12 \times 306 = 3,672$ transport signal blocks. In
                  these blocks $3,672 \times 856 = 3,143,232$ bits should be processed; this would
                  require a maximum-length sequence of $2^{22}-1$ bit, which means that the highest

power in the polynomial should be at least 22. However, this solution is in conflict with compliance with the second criterion: a short maximum-length sequence. The arrangement in accordance with the invention utilizes a solution which meets both criteria: a data sequence generator which generates a shorter

5   maximum-length sequence, whose preset value can be different for all the recording signal blocks in a given period. One period of 12 tracks comprises 3,672 transport signal blocks; this means that with a 12-bit preset value all the recording signal blocks within a period if 12 tracks can be scrambled with a different data sub-sequence. Owing to this solution a maximum-length sequence

10   of $2^{12}-1$ bit is now adequate, i.e. the highest power in the polynomial should be at least 12.

For practical reasons, which lead to an advantageous implementation of the recording/reproducing arrangement, the following design criteria are important:

3).   The number of feedback loops and XOR circuits in the data sequence generator

15   should be minimal; preferably one.

4).   A multiplicity of bits, preferably at least eight, should be made available simultaneously by the data sequence generator, so as to enable an implementation in which a multiplicity of bits of the recording signal is scrambled at the same time. Moreover, it should be possible for the data

20   sequence generator to be adapted simply in such a manner that the generation of such a multiplicity of bits of the data sequence is effected with a frequency lower than the bit rate of the recording signal, for example a frequency which is eight times as low. All these design criteria are met in an excellent way by a data sequence generator which generates a data sequence of the maximum-

25   length sequence type, which is defined by the polynomial $P(X) = X^{15} + X^7 + 1$ or by the polynomial $P(X) = X^{15} + X^x + 1$. These polynomials in fact define identical maximum-length sequences which are mirror-inverted in time relative to one another.

During recording the recording signal is scrambled in order to obtain the

30   channel signal which is recorded on the magnetic tape after a further processing comprising the division into data blocks described herein and the addition of a synchronization pattern and error correction data. During reproduction the signal read from the tape is processed in an inverse manner and the channel signal thus obtained is descrambled. Both the scrambling process and the descrambling process comprise the combination of the signal to be processed

with the generated data sequence in order to obtain a processed signal. Therefore, it is advantageous to provide a recording/reproducing arrangement with only one coding device and to provide the latter with selection means to select, depending on whether the arrangement is in a recording mode or a reproduction mode, either the recording signal or

5   the channel signal read from the magnetic tape for combination with the generated data sequence. The signal to be processed can be combined with the data sequence by means of, for example, a mixer such as a double-balanced mixer circuit. However, a preferred embodiment is characterized in that the coding device further comprises modulo-2 adding means for combining the generated data sequence with the signal to be processed, i.e. either

10   the digital recording signal or the channel signal read from the magnetic tape, in order to obtain a processed signal, i.e. the channel signal to be recorded on the magnetic tape, or the digital reproduction signal. Advantages of the use of modulo-2 adding means, such as an XOR circuit (eXclusive-OR), for combining the signal to be processed with the data sequence are that modulo-2 adding means can simply be included in a digital circuit arrangement and

15   the modulo-2 adding means, in contradistinction to many mixer circuits, do not produce a shift in signal level. The modulo-2 adding means can be implemented in such a manner that always one bit of the signal to be processed is combined with one bit of the generated data sequence, but in implementations which perform other operations on a plurality of bits at a time it is advantageous to perform the scrambling/descrambling operation also on a plurality

20   of bits at a time. To this end a preferred embodiment is characterized in that the data sequence generator is adapted to generated an N-bit word, and the modulo-2 adding means comprise N XOR circuits (eXclusive-OR) together arranged to combine the N-bit word from the data sequence generator with an N-bit word of the signal to be processed, in order to obtain an N-bit word of the processed signal, where $N > 1$. The data sequence generator can

25   be implemented in such a manner that bits of the data sequence are generated with a high frequency corresponding to the bit rate of the signal to be processed. These bits can be supplied one by one and combined with one bit of the signal to be processed, or the bits can be supplied and combined in N-bit words. In the last-mentioned case supplying and combining is effected with a frequency which corresponds to the bit rate of the signal to be

30   processed, divided by N. An embodiment which is characterized in that the data sequence generator is adapted to generate N-bit words, said words being generated with a frequency corresponding to the bit rate of the signal to be processed divided by N, has the advantage that the data sequence generator also operates at a lower frequency. This reduces the current consumption of the data sequence generator circuit and it also allows the circuit to be

realized in an IC process yielding less rapid circuits. The number, N, of bits generated and processed as a word is preferably selected in accordance with the word length used in the other operations. Frequently used word lengths are eight and sixteen.

A further embodiment of the recording/reproducing arrangement in accordance with the invention is characterized in that the data sequence generator comprises fifteen serially coupled memory elements ($M_1..M_{15}$) and an XOR circuit, the memory element M_k, where k = 1..14, having its output coupled to the input of the memory element M_{k+1}, the last memory element (M_{15}) having its output coupled to an input of the XOR circuit, and the seventh or the eighth memory element (M_A) having its output coupled to the other input of the XOR circuit, and the XOR circuit having its output coupled to the input of the first memory element (M_1). This data sequence generator is adapted to generate bits of the data sequence at a high frequency corresponding to the bit rate of the signal to be processed. These bits can be taken one by one from the output of a memory element, for example M_{15}, and are combined with one bit of the signal to be processed, or the bits can be taken in N-bit words from N consecutively numbered memory elements, for example M_8 - M_{15}, N being for example eight, and can be combined at the same time as an N-bit word with an N-bit word of the signal to be processed. In the last-mentioned case reading out and combining is effected with a frequency corresponding to the bit rate of the signal to be processed, divided by N. This embodiment is also suitable for use in an implementation in which 16-bit words are processed, if the data sequence generator further comprises a memory element M_{16}, the memory element M_{15} having its output coupled to the input of the memory element M_{16}. A 16-bit word of the data sequence is now taken from the memory elements M_1 - M_{16} and combined with a 16-bit word of the signal to be processed. If the embodiment is used in this manner, reading out and combining is effected with a frequency corresponding to the bit rate of the signal to be processed, divided by sixteen.

An embodiment of the recording/reproducing arrangement is characterized in that A = 7, the data sequence generator comprises fifteen coupled memory elements ($M_1..M_{15}$) and eight XOR circuits ($X_1..X_8$), the XOR circuit X_n having its output coupled to the input of the memory element M_n, where n = 1...7, the memory element M_n has its output coupled to the input of the memory element M_{n+8} and to an input of the XOR circuit X_{n+1}, the memory element M_{n+8} has its output coupled to the other input of the XOR circuit X_{n+1}, the XOR circuit X_8 has its output coupled to the input of the memory element M_8 and to an input of the XOR circuit X_1, and the memory element M_8 has its output coupled to the other input of the XOR circuit X_1. This data sequence generator is adapted to

generate 8-bit words of the data sequence at a lower frequency corresponding to the bit rate of the signal to be processed, divided by eight. Such an 8-bit word is taken from eight consecutively numbered memory elements, for example M_8 - M_{15}, and combined with an 8-bit word of the signal to be processed. Reading out and combining is also effected with a frequency corresponding to the bit rate of the signal to be processed, divided by eight. This embodiment is also suitable for use in an implementation in which 16-bit words are processed, if the data sequence generator further comprises a memory element M_{16}, the memory element M_8 having its output coupled to the input of the memory element M_{16}. A 16-bit word of the data sequence is now taken from the memory elements M_1 - M_{16} and combined with a 16-bit word of the signal to be processed. If the embodiment is used in this manner, reading out and combining is effected with a frequency corresponding to the bit rate of the signal to be processed, divided by sixteen.

The embodiments are also suitable for use in an implementation in which 16-bit words are processed, if the data sequence generator further comprises eight memory elements M_{16} - M_{23}, the outputs of eight consecutively numbered memory elements, for example the memory elements M_8 - M_{15} being coupled to the inputs of the memory elements M_{16} - M_{23}. The data sequence generator generates a first 8-bit word in the memory elements M_8 - M_{15}, stores this word in the eight memory elements M_{16} - M_{23}, and subsequently generates a second 8-bit word in the memory elements M_8 - M_{15}. A 16-bit word of the data sequence is now taken from the memory elements M_8 - M_{23} and combined with a 16-bit word of the signal to be processed, reading out and combining being effected with a frequency corresponding to the bit rate of the signal to be processed, divided by sixteen.

It is to be noted that polynomials $P(X) = X^{15} + X^7 + 1$ and $P(X) = X^{15} + X^x + 1$ define basically identical data sequences which are mirror-inverted in time relative to one another. Processing of a data block by means of the one data sequence will therefore yield the same result as processing by means of the other data sequence, provided that this processing is also effected mirror-inverted in time, i.e. the last bit of the data block is processed first, then the penultimate bit etc., and finally the first bit of the data block. Since a recording/reproducing arrangement for digital signals comprises several buffers which store data blocks temporarily for further signal processing, it is readily possible to apply the recording signal blocks to the coding device in time-inverted form, to combine these time-inverted blocks with said other data sequence in this device, and to store the resulting time-inverted channel signal blocks in a buffer and to time-invert them again for recording on the tape. During reproduction the channel signal blocks can be processed in a similar inverted

manner in order to obtain the reproduction signal blocks.

A magnetic-tape recording/reproducing arrangement in accordance with the invention is particularly suitable for recording and/or reproducing a digitally coded video signal because in such an arrangement it is of great importance that the objects of the

5   invention are achieved. However, it is to be noted that a magnetic-tape recording/reproducing arrangement need not necessarily comprise source encoding means and/or source decoding means; conversion of an (analog) video signal into, for example, an MPEG-coded video signal and vice versa may be effected outside the recording/reproducing arrangement. Since it is not relevant for the invention where this source encoding and/or source decoding is

10   effected, the invention also relates to recording/reproducing arrangements which do not comprise source encoding means and/or source decoding means and which are therefore also suitable for recording and/or reproducing digital signals other than digitally coded video signals, such as for example computer data and digitally coded audio signals.

Furthermore, it is to be noted that in cases where a magnetic-tape

15   recording/reproducing arrangement is referred as being of the "helical scan" type, the invention likewise relates to all magnetic-tape recording/reproducing arrangements using rotary heads for writing and reading tracks which are inclined relative to the transport direction of the magnetic tape. Therefore, this is to be understood to include also arrangements of the "transversal scan" type and arrangements of the "arcuate scan" type.

20

The invention will now be described in more detail, by way of example, with reference to the drawings. In the drawings:

Figure 1 is a block diagram of a magnetic-tape recording/reproducing arrangement in accordance with the invention,

25   Figure 2 shows an embodiment of the coding device,

Figure 3 shows another embodiment of the coding device,

Figure 4 shows yet another embodiment of the coding device.

The block diagram in Figure 1 shows diagrammatically those parts of a

30   magnetic-tape recording/reproducing arrangement in accordance with the invention which are relevant for a correct understanding of the invention.

When the arrangement is in a recording mode the signal to be recorded is subjected to the following operations:

- Source encoding. If the signal A to be recorded and applied to the input 1a is an analog

video signal, it is first converted into, for example, an MPEG coded video signal in the source encoding means 1. The resulting digital signal B is referred to hereinafter as the incoming digital signal.

- Block structuring. The incoming digital signal B is divided into groups of 792 bits in the

5 processing means 2, after which error-correction data is added to each group. Thus, recording signal blocks of 856 bits each are obtained, the resulting recording signal C comprises a stream of these recording signal blocks.

- Channel coding. During recording the signal selection means 3.1 are in the position shown, as a result of which the recording signal C is further processed in the coding device 3 in

10 order to obtain the channel signal D. This processing comprises the combining, in an XOR circuit 3.2, of the recording signal C with a data sequence E, which is generated in a data sequence generator 3.3. This data sequence generator generates a maximum-length sequence defined by the polynomial $P(X) = X^{15} + X^7 + 1$. Since the recording signal C has a block structure (recording signal blocks), the resulting channel signal D also has a block structure;

15 channel signal blocks.

- Synchronization preparation. During recording the resulting channel signal D is applied to the synchronization preparation means 5 by signal routing means 4. In the synchronization preparation means a synchronization pattern is added to each channel signal block, resulting in a transport signal block. The transport signal block F thus obtained comprises a stream of

20 transport signal blocks for recording.

- Recording. The transport signal is applied to a write/read device 7 via switching means 6, which write/read device records the signal on a magnetic tape 7.1 after preparatory processing for recording. The write/read device writes helical tracks on the magnetic tape; a track as recorded on the tape comprises 306 transport signal blocks.

25 When the arrangement is in a reproducing mode the signal to be reproduced is subjected to the following operations:

- Reading. The write/read device 7 reads a signal from the magnetic tape 7.1, processes this signal to obtain a digital transport signal G and applies this transport signal to synchronization means 8 via switching means 6 (which during reproduction are in another

30 position than the position shown).

- Synchronization. The synchronization means 8 check the transport signal G for the presence of synchronization patterns. If these patterns are detected the transport signal is divided into transport signal blocks. From these transport signal blocks the channel signal blocks are extracted and output in the channel signal H.

- Channel decoding. The channel signal H is applied to the coding device 3. During reproduction the signal selection means 3.1 are in another position than the position shown. In the coding device 3 the channel signal H is processed in order to obtain the reproduction signal I. This processing corresponds to the processing during recording and thus cancels the

5 processing during recording. The processing comprises the combining, in an XOR circuit 3.2, of the channel signal H with a data sequence E generated in the data sequence generator 3.3. The data sequence generator generates a maximum-length sequence defined by the polynomial $P(X) = X^{15} + X^7 + 1$.

- Signal structuring. During reproduction the resulting reproduction signal I is applied to the

10 processing means 9 by signal routing means 4 (which are now in another position than the position shown). In these processing means error correction is applied, after which the signal is rid of the block structure applied in the processing means 2 in the recording mode. At the output 9a of the processing means 9 this yields the digital outgoing signal J which is a replica of the original digital incoming signal B.

15 - Source decoding. The digital outgoing signal J at the output 9a 9s, for example, an MPEG coded video signal. In the source decoding means 10 this signal is converted into an analog video signal K, which is subsequently available at the output 10a in order to be applied to, for example, a television receiver.

In another embodiment of the magnetic-tape recording/reproducing arrangement in

20 accordance with the invention the arrangement does not include source encoding means 1. Such an embodiment is advantageous when an MPEG coded video signal is transmitted and is consequently available at the output of the tuner (not shown), and also when a digitally coded video signal from another source, for example a camera or a set-top box, is available. Thus, in this embodiment an incoming digital signal can be applied directly to the input 2a,

25 without the use of any further source encoding.

In yet another embodiment the magnetic-tape recording/reproducing arrangement in accordance with the invention does not comprise source decoding means 10. Such an embodiment is advantageous when an MPEG coded video signal can be processed further outside the recording/reproducing arrangement, for example in the television set. In this

30 embodiment the digital signal J is available directly from the output 9a, i.e. without the use of any further source decoding.

These two alternative embodiments can also be combined to form an embodiment without source encoding and decoding means.

Figure 2 shows an embodiment of the coding device 3. This embodiment

comprises a data sequence generator 3.3, comprising fifteen serially coupled memory elements $M_1..M_{15}$ and one XOR circuit X_1. The output of each of the memory elements $M_1..M_{14}$ is coupled to the input of the memory element bearing the next high number. The output of the last memory element M_{15} and the output of the seventh memory element M_7 are each coupled to an input of the XOR circuit X_1. The output of this XOR circuit X_1 is coupled to the input of the first memory element M_1.

The data sequence generator further comprises trigger-signal paths, not shown in this Figure: Each memory element has a trigger input for receiving a trigger signal. When a trigger signal is received the data bit on the input of the memory element is loaded into the memory element and is transferred to its output. The trigger inputs of the memory elements have been coupled to one another and receive a trigger signal of a frequency corresponding to the bit rate of the recording signal C. The data sequence generator further comprises preset-signal paths, neither shown in this Figure: Each memory element has a preset input for receiving one bit of a preset signal and a preset-enable input for receiving a preset-enable signal. When the preset-enable signal is received the bit on the preset input of the memory element is loaded into the memory element and is transferred to its output. The preset enable inputs of the memory elements have been coupled to one another and receive a preset-enable signal for each recording signal block in the recording signal C. The preset signal (15 bits) is always adjusted in such a manner that all recording signal blocks within a period of 12 tracks are scrambled with a different data sub-sequence.

The data sequence E is taken from the generator at the output of the memory element M_{15}. The coding device further comprises an XOR circuit 3.2 for combining the data sequence E with the recording signal C so as to obtain the channel signal D.

Figure 3 shows another embodiment of the coding device. In this embodiment the data sequence generator 3.3 is of a construction similar to that in Figure 2, with the exception that now 8 bits of the data sequence E are taken from the generator, at the outputs of the memory elements $M_8..M_{15}$. In 8 XOR circuits $3.2_1..3.2_8$ this 8-bit word $E_1..E_8$ is combined with an 8-bit word $C_1..C_8$ of the recording signal C, in order to obtain an 8-bit word $D_1..D_8$ of the channel signal D. Similarly to the embodiment shown in Figure 2, the data sequence generator of Figure 3 further comprises trigger-signal paths and preset-signal paths, not shown in the present Figure. In the present embodiment the trigger inputs of the memory elements $M_1..M_{15}$ likewise receive a trigger signal of a frequency corresponding to the bit rate of the recording signal C, but the 8-bit word $D_1..D_8$ of the channel signal D is to be read out with a frequency which is only 8 times as low for further processing.

Consequently, the 8-bit word $C_1..C_8$ of the recording signal C need also be applied with this frequency which is only 8 times as low. Therefore, this embodiment is advantageous in implementations which perform operations upon 8-bit words.

5   The embodiments of the coding device 3 as shown in Figures 2 and 3 have been constructed to generate a data sequence defined by the polynomial $P(X) = X^{15} + X^7 + 1$. These embodiments can simply be adapted to generate a data sequence defined by the polynomial $P(X) = X^{15} + X^8 + 1$. For this purpose, the output of the eighth memory element M_8 is coupled to the input of the XOR circuit X_1 instead of to the output of the seventh memory element M_7.

10   Figure 4 shows yet another embodiment of the coding device 3, adapted to generate a data sequence defined by the polynomial $P(X) = X^{15} + X^7 + 1$. This embodiment has a data sequence generator 3.3 comprising fifteen coupled memory elements $M_1..M_{15}$ and eight XOR circuits $X_1..X_8$. The XOR circuit X_8 has its output coupled to the input of the memory element M_8 and to an input of the XOR circuit X_1. The memory

15   element M_8 has its output coupled to the other input of the XOR circuit X_1. Furthermore, the memory elements and XOR circuits are coupled as seven identical sub-configurations, $n = 1..7$: The XOR circuit X_n has its output coupled to the input of the memory element M_n. The memory element M_n has its output coupled to the input of the memory element M_{n+8} and to an input of XOR circuit X_{n+1}. The memory element M_{n+8} has its output coupled to

20   the other input of the XOR circuit X_{n+1}.

Each time 8 bits of the data sequence E are taken from the memory elements $M_8..M_{15}$. In 8 XOR circuits $3.2_1..3.2_8$ this 8-bit word $E_1..E_8$ is combined with an 8-bit word $C_1..C_8$ of the recording signal C in order to obtain an 8-bit word $D_1..D_8$ of the channel signal D. Similarly to the embodiment shown in Figure 2 the data sequence generator of Figure 4

25   further comprises trigger-signal paths and preset-signal paths, not shown in the present Figure. In the present embodiment the trigger inputs of the memory elements $M_1..M_{15}$ likewise receive a trigger signal of a lower frequency corresponding to the bit rate of the recording signal C divided by 8. The -bit word $D_1..D_8$ of the channel signal D need also be read out with this lower frequency for further processing. Therefore, this embodiment is

30   advantageous in implementations which perform operations upon 8-bit words and, moreover, this embodiment has a lower current consumption because the data sequence generator operates at a lower frequency.

For embodiments shown in Figures 2, 3 and 4 the signals have been indicated as processed and supplied by the coding device during recording: the recording

signal C and the channel signal D. However, these embodiments are equally suited for use in a reproduction mode; the signal to be processed is then the channel signal H and the processed signal is then the reproduction signal I. These embodiments may also be provided with signal selection means (3.1 in Figure 1) in order to select, depending on whether the

5   arrangement is in a recording or a reproduction mode, the recording signal C or the channel signal H read from the magnetic tape in order to be combined with the generated data sequence E.

The invention thus provides a magnetic-tape recording/reproducing arrangement of the "helical scan" type constructed to record and/or reproduce a digitally

10   coded video signal and comprising a coding device. In the recording mode the coding device processes a digital recording signal (channel encoding) so as to obtain a channel signal to be recorded on the magnetic tape. In the reproduction mode the coding devices processes the channel signal read from the magnetic tape (channel decoding) so as to obtain a digital reproduction signal which is a replica of the original recording signal. For this purpose, the

15   coding device comprises a data sequence generator adapted to generate a data sequence defined by the polynomial $P(X) = X^{15} + X^7 + 1$ or by the polynomial $P(X) = X^{15} + X^8 + 1$. Moreover, the coding device preferably comprises modulo-2 adding means, in which the signal to be processed is combined with the generated data sequence, and selection means with which the signal to be processed is selected from the recording signal and the channel

20   signal, depending on the mode of operation of the recording/reproducing arrangement. The invention further provides embodiments of the coding device adapted to generate N-bit words of the data sequence and to combine these N-bit words with N-bit words of the signal to be processed.

It is to be noted that the invention is not limited to the preferred

25   embodiments described herein. Those skilled in the art will be able to envisage variants which fall within the scope of the invention as defined in the following Claims. Thus, the data sequence generator, for example, can also be implemented with a memory, such as a 4kx8 ROM, in which the data sequence has been preprogrammed. One word of the data sequence, for example an 8-bit word, is read from the memory, after which the memory is

30   addressed in such a manner that the next word of the data sequence becomes available for read-out. By starting the read-out of the data sequence at a suitable ROM address for each recording signal block it is achieved that all recording signal blocks within a period of 12 tracks are scrambled with different data sub-sequences. Furthermore, although it has been described here in terms of hardware means, the invention can also be realized by a software

program which controls the functions of a programmable device, such as a microprocessor or a digital signal processor. Such realizations also fall within the scope of the invention. It is particularly advantageous to incorporate the invention in a software program which also performs other signal processing functions for recording and/or reading a digital signal, and

5   to select for this purpose an embodiment adapted, as described hereinbefore, to the word length used in these other signal processing functions.

CLAIMS:

1.   A magnetic-tape recording/reproducing arrangement of the "helical scan"
type adapted to record and/or reproduce a digitally coded video signal, the arrangement
comprising a coding device adapted to perform channel-encoding upon a digital recording
signal in order to obtain a channel signal for recording on the magnetic tape and/or to
5   perform channel-decoding upon a channel signal read from the magnetic tape in order to
obtain a digital reproduction signal, characterized in that the coding device comprises a data
sequence generator adapted to generate a data sequence defined by the polynomial $P(X) = X^{15} + X^A + 1$, where $A = 7$ or 8.

2.   A magnetic-tape recording/reproducing arrangement as claimed in Claim
10   1, characterized in that the coding device further comprises modulo-2 adding means for
combining the generated data sequence with the signal to be processed, i.e. either the digital
recording signal or the channel signal read from the magnetic tape, in order to obtain a
processed signal, i.e. the channel signal to be recorded on the magnetic tape, or the digital
reproduction signal.

15   3.   A magnetic-tape recording/reproducing arrangement as claimed in Claim
2, characterized in that the data sequence generator is adapted to generated an N-bit word,
and the modulo-2 adding means comprise N XOR circuits (eXclusive-OR) together arranged
to combine the N-bit word from the data sequence generator with an N-bit word of the signal
to be processed, in order to obtain an N-bit word of the processed signal, where $N > 1$.

20   4.   A magnetic-tape recording/reproducing arrangement as claimed in Claim
3, characterized in that the data sequence generator is adapted to generate N-bit words, said
words being generated with a frequency corresponding to the bit rate of the signal to be
processed divided by N.

5.   A magnetic-tape recording/reproducing arrangement as claimed in Claim 3
25   or 4, characterized in that $N = 8$.

6.   A magnetic-tape recording/reproducing arrangement as claimed in Claim 3
or 4, characterized in that $N = 16$.

7.   A magnetic-tape recording/reproducing arrangement as claimed in Claim
1, 2 or 3, characterized in that the data sequence generator comprises fifteen serially coupled

memory elements $(M_1..M_{15})$ and an XOR circuit, the memory element M_k, where k = 1..14, having its output coupled to the input of the memory element M_{k+1}, the last memory element (M_{15}) having its output coupled to an input of the XOR circuit, and the seventh or the eighth memory element (M_A) having its output coupled to the other input of the XOR

5   circuit, and the XOR circuit having its output coupled to the input of the first memory element (M_1).

8.   A magnetic-tape recording/reproducing arrangement as claimed in Claim 1, 2, 3 or 4, characterized in that A = 7, the data sequence generator comprises fifteen coupled memory elements $(M_1..M_{15})$ and eight XOR circuits $(X_1..X_8)$, the XOR circuit X_n

10   having its output coupled to the input of the memory element M_n, where n = 1...7, the memory element M_n has its output coupled to the input of the memory element M_{n+8} and to an input of the XOR circuit X_{n+1}, the memory element M_{n+8} has its output coupled to the other input of the XOR circuit X_{n+1}, the XOR circuit X_8 has its output coupled to the input of the memory element M_8 and to an input of the XOR circuit X_1, and the memory element

15   M_8 has its output coupled to the other input of the XOR circuit X_1.

9.   A magnetic-tape recording/reproducing arrangement as claimed in Claim 7 or 8 where appendant to Claim 3, characterized in that of each of N consecutively numbered memory elements $(M_{x+1}..M_{x+N})$ has its output coupled to an input of one of the N XOR circuits of the modulo-2 adding means.

20   10.   A magnetic-tape recording/reproducing arrangement as claimed in Claim 9, characterized in that N = 8.

11.   A magnetic-tape recording/reproducing arrangement as claimed in any one of the preceding Claims, characterized in that the coding device further comprises selection means adapted to select the signal to be processed from the digital recording signal and the

25   channel signal read from the magnetic tape.

12.   A coding device for use in a magnetic-tape recording/reproducing arrangement of the "helical scan" type as claimed in any one of the preceding Claims, characterized in that the coding device comprises:
- means for selecting one of a plurality of input signals,

30   - a data sequence generator adapted to generate a data sequence defined by the polynomial $P(X) = X^{15} + X^A + 1$, where A = 7 or 8,
- means for combining the selected input signal with the generated data sequence.

13.   A method of recording a digitally coded video signal in helical tracks on a magnetic tape by channel encoding of a digital recording signal in order to obtain a channel

signal for recording on the magnetic tape, characterized in that the channel encoding comprises the steps of:

- generating a data sequence defined by the polynomial $P(X) = X^{15} + X^A + 1$, where $A = 7$ or 8.

5   - combining the recording signal with the generated data sequence.

14.   A magnetic tape on which a signal has been recorded in helical tracks, characterized in that the signal has been encoded by combination with a data sequence defined by the polynomial $P(X) = X^{15} + X^A + 1$, where $A = 7$ or 8.
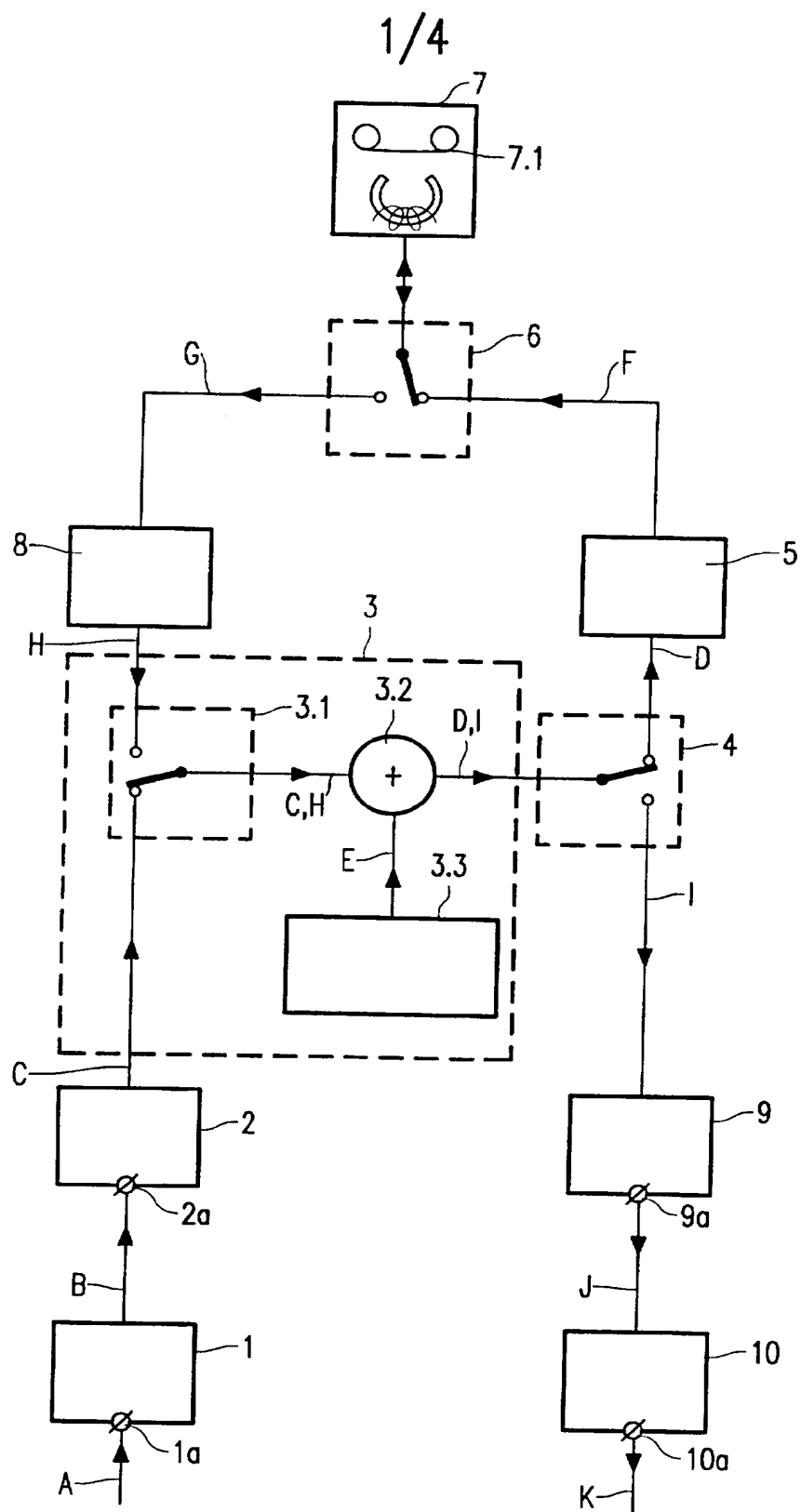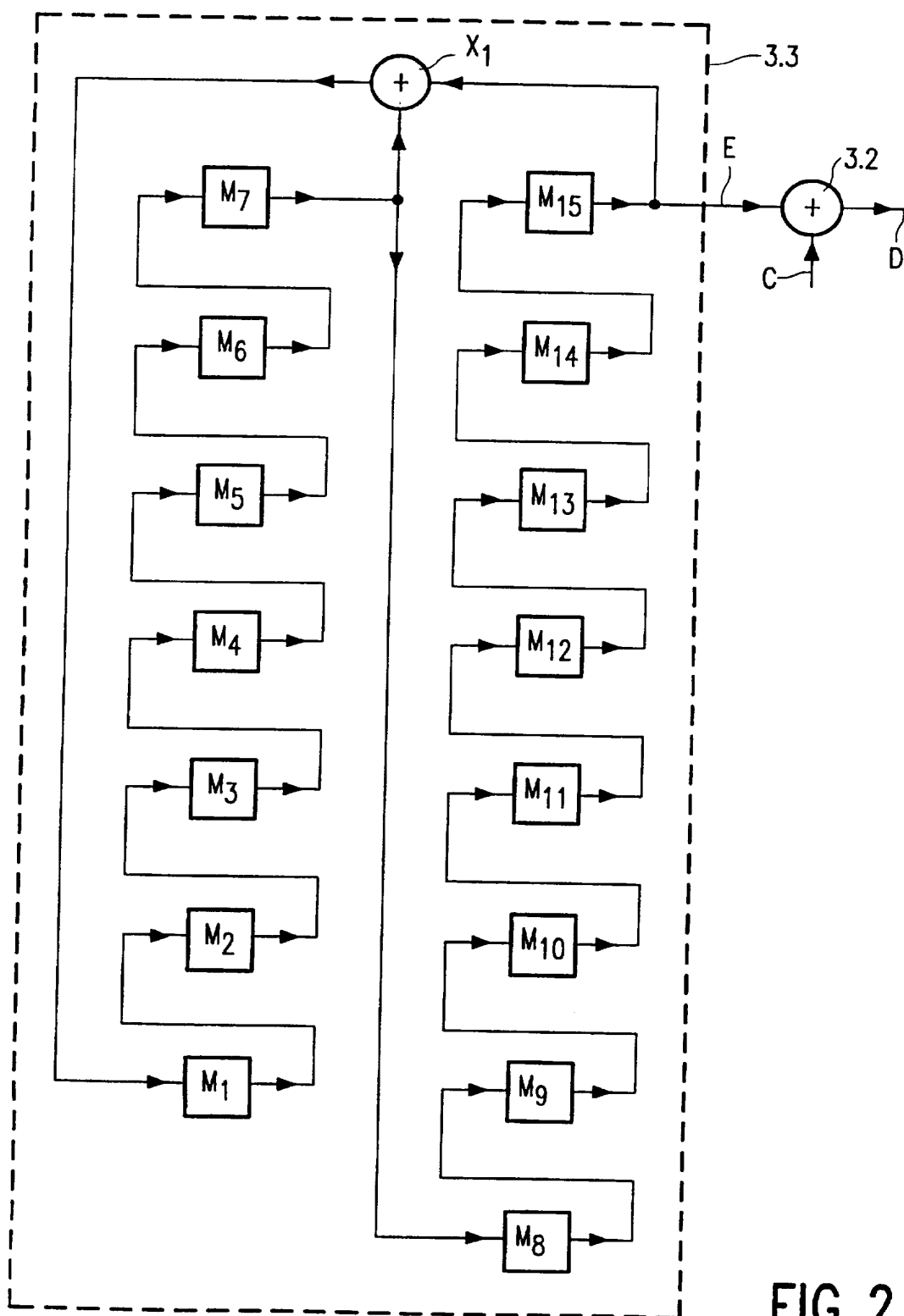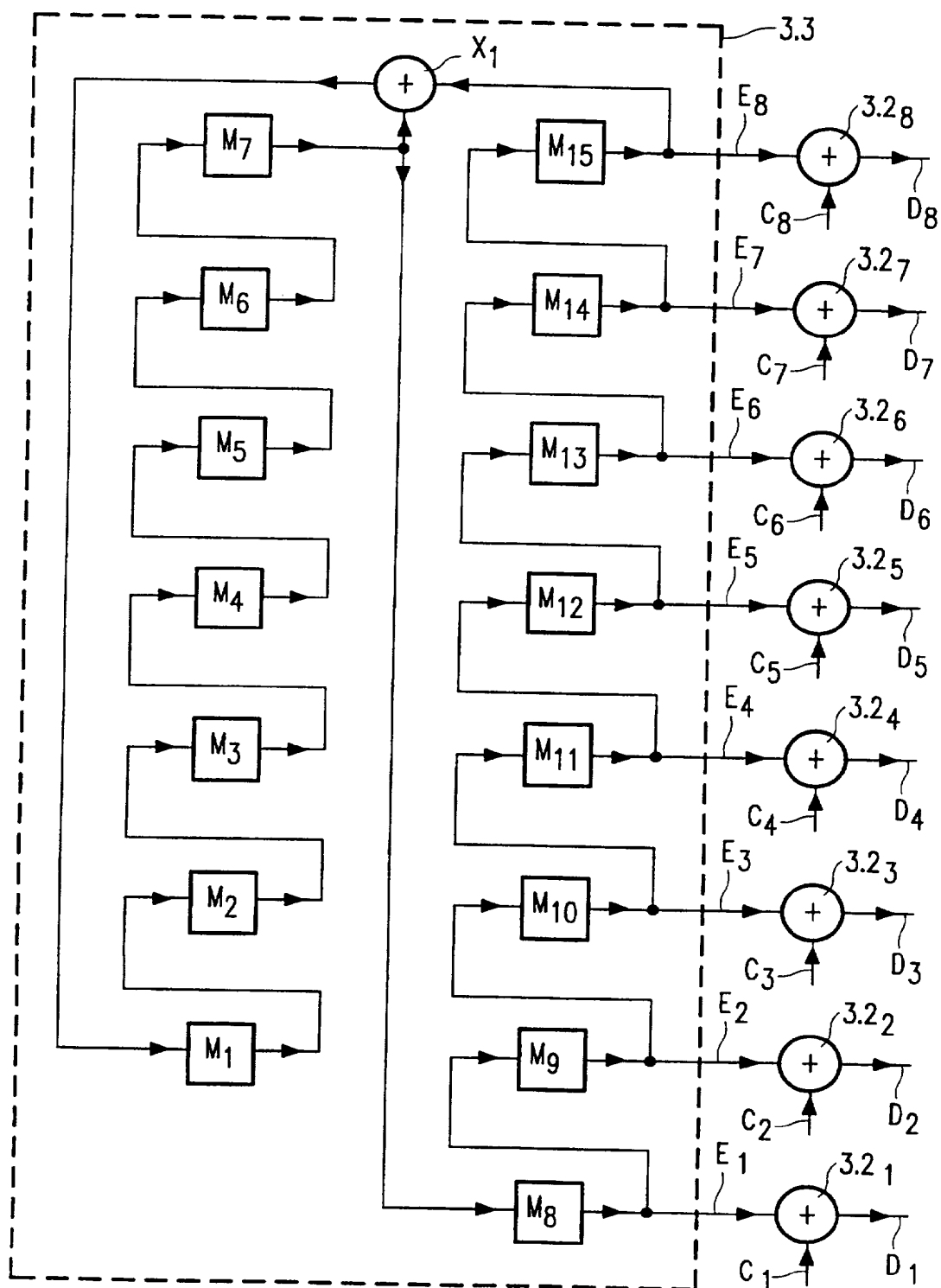
1/4

FIG. 1

FIG. 2

FIG. 3

4/4
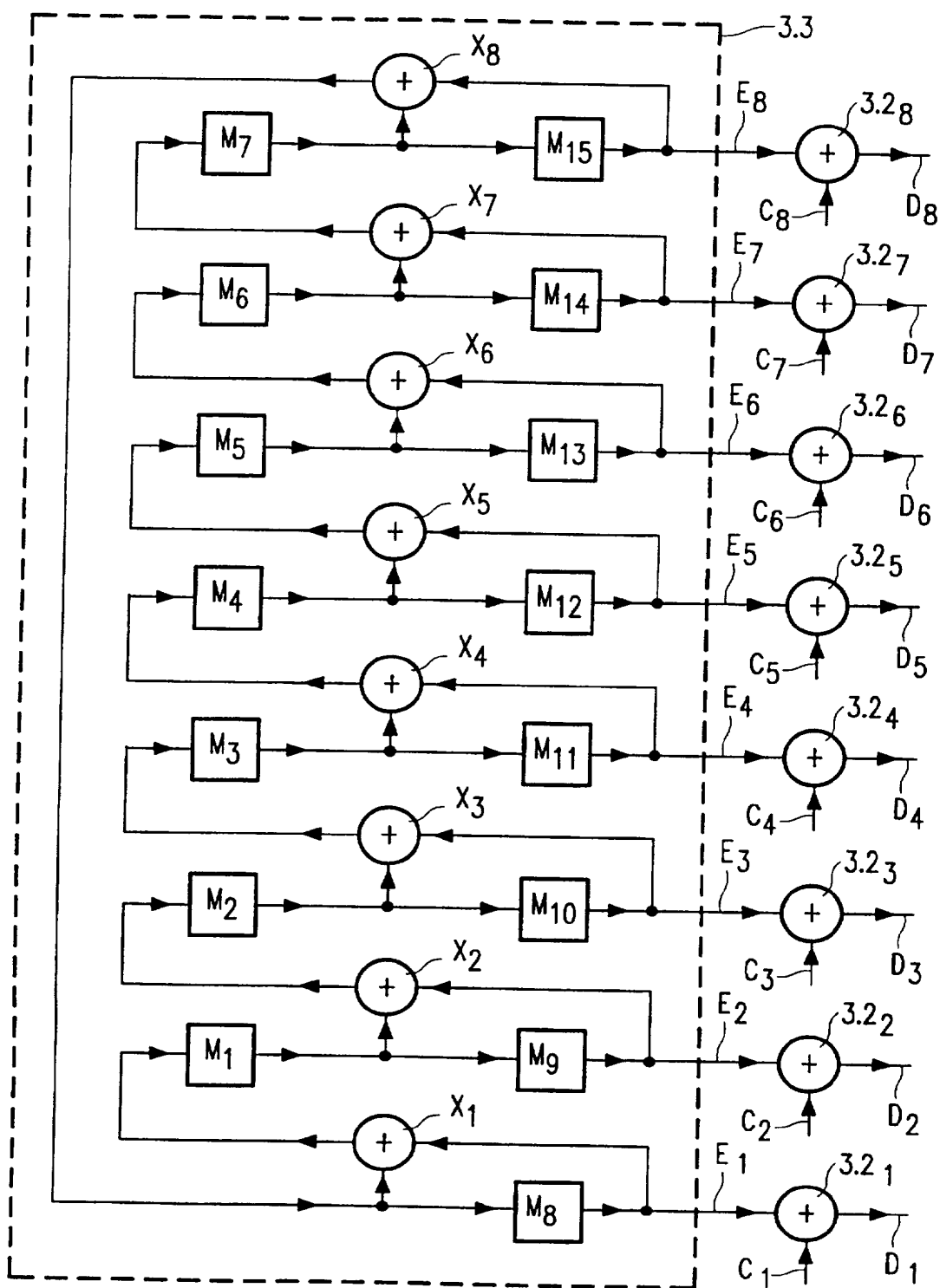

FIG. 4

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IB 97/00397

A. CLASSIFICATION OF SUBJECT MATTER

IPC6: H04N 5/08, H04N 7/167

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC6: H04N, G11B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	EP 0641130 A1 (MATSUSHITA ELECTRIC INDUSTRIAL CO., LTD.), 1 March 1995 (01.03.95), column 1, line 22 - line 30; column 2, line 20 - line 32; column 3, line 3 - line 14, column 8, line 29 - line 34; column 12, line 6 - line 14, claims 2,8, 11, abstract	1-13
A	US 5301033 A (BYUNG-HOAN CHON), 5 April 1994 (05.04.94), abstract	1-13
A	US 4337483 A (LOUIS C. GUILLOU), 29 June 1982 (29.06.82), column 11, line 11 - line 15, abstract	1-13

X	Further documents are listed in the continuation of Box C.	X	See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" erlier document but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
7 October 1997	0 8 -10- 1997

Name and mailing address of the ISA/	Authorized officer
Swedish Patent Office Box 5055, S-102 42 STOCKHOLM Facsimile No. +46 8 666 02 86	Rune Bengtsson Telephone No. +46 8 782 25 00

Form PCT/ISA/210 (second sheet) (July 1992)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/00397

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 0476767 A1 (N.V. PHILIPS' GLOEILAMPENFABRIEKEN), 25 March 1992 (25.03.92), see whole document -- --------	1-13

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IB 97/00397

| **Box I** | Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet) |

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☒ Claims Nos.: 14
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

The claimed tape is not considered characterized by the specific stored signal.

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

| **Box II** | Observations where unity of invention is lacking (Continuation of Item 2 of first sheet) |

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest ☐ The additional search fees were accompanied by the applicant's protest. _

☐ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet (1)) (July 1992)

INTERNATIONAL SEARCH REPORT
Information on patent family members

International application No.

PCT/IB 97/00397

Patent document cited in search report		Publication date	Patent family member(s)		Publication date
EP	0641130 A1	01/03/95	CN	1112340 A	22/11/95
			JP	7067096 A	10/03/95
			US	5515437 A	07/05/96
			JP	7135648 A	23/05/95
US	5301033 A	05/04/94	JP	2561783 B	11/12/96
			JP	6169432 A	14/06/94
			KR	9408492 B	15/09/94
US	4337483 A	29/06/82	BR	8006308 A	30/12/80
			CA	1150820 A	26/07/83
			EP	0014652 A,B	20/08/80
			SE	0014652 T3	
			FR	2448824 A,B	05/09/80
			JP	3018396 B	12/03/91
			JP	56500076 T	22/01/81
			SU	1172456 A	07/08/85
			WO	8001636 A	07/08/80
EP	0476767 A1	25/03/92	SE	0476767 T3	
			AT	136149 T	15/04/96
			AU	643921 B	25/11/93
			CN	1027664 B	15/02/95
			CN	1059987 A	01/04/92
			CZ	9102853 A	17/08/94
			DE	69118288 D,T	02/10/96
			ES	2088785 T	16/09/96
			JP	4255969 A	10/09/92
			NL	9002069 A	16/04/92
			NL	9002772 A	16/04/92
			RU	2067781 C	10/10/96
			SK	285391 A	05/01/95
			US	5142421 A	25/08/92